



# RESOURCE-21

R. Higgins

The Boeing Co.

253-657-8070

[robert.p.higgins@boeing.com](mailto:robert.p.higgins@boeing.com)



# RESOURCE-21

- Earth resources sensing system
  - Multi-spectral image sensor
  - Push-broom configuration
  - Compressed image data downlink in X-band
  - TT&C downlink in X-band
  - TT&C uplink in S-band



# Orbit Parameters

- Epoch Date 4/1/2006 09:31:37 UTCG
- Apogee Alt\* 714 km
- Perigee Alt\* 697 km
- Eccentricity\*\* 0.001186
- Inclination 98.21°
- Arg. of Peri. 90°
- RAAN 159.59°
- Mean Anom. 58.56°

\* Altitude referenced to a mean equatorial radius of 6378.137km.

\*\* Non-zero eccentricity approximates the nominal 'frozen orbit.'

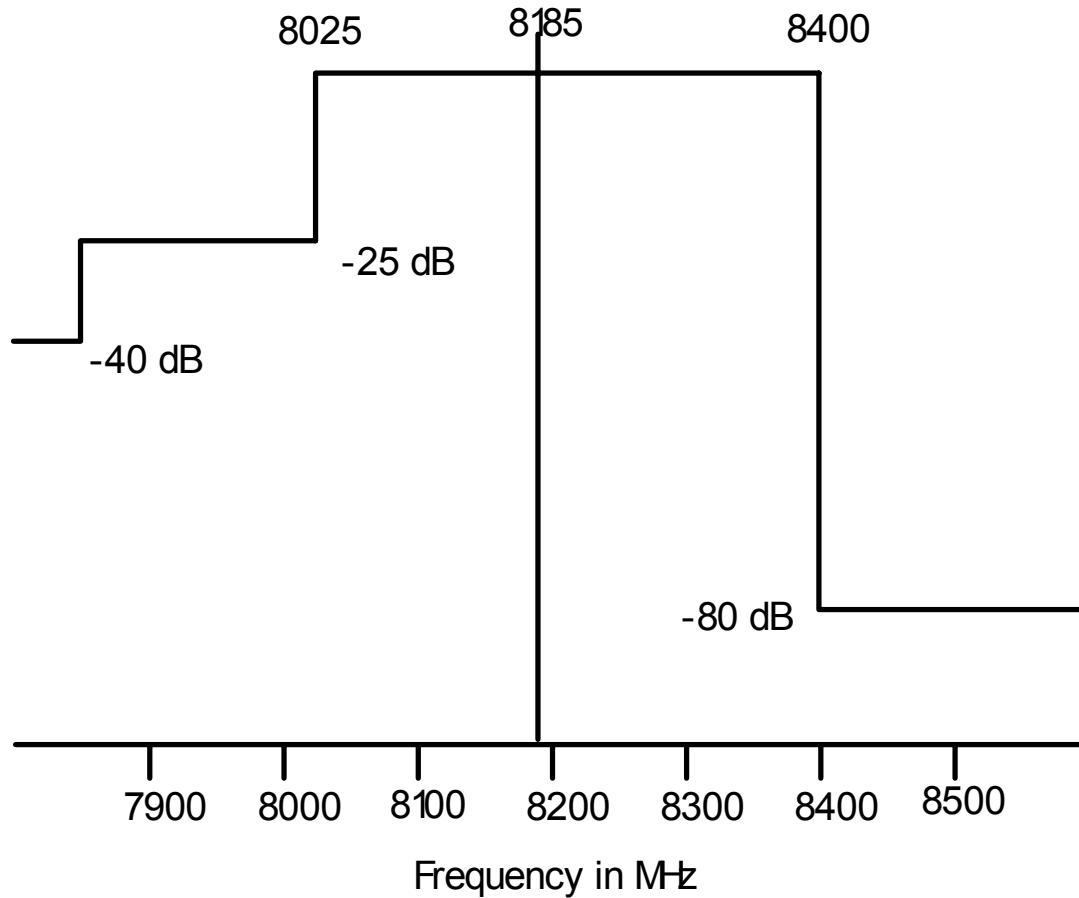


# Wideband Downlink Characteristics



Characteristic	Value	Units
Center Frequency	8185	MHz
Noise Equivalent Bandwidth	200	MHz
Polarization	Dual Circular	
Modulation	OQPSK	
Filtering	RRC $\beta=0.625$	
FEC coding	R-S(255,223)	
BER	$10^{-12}$	
Availability Objective	99.7	%
Output Power (nominal)	1.57	Watts
EIRP (nominal)	28.6	dBW
Emission Designator	325MG7D	

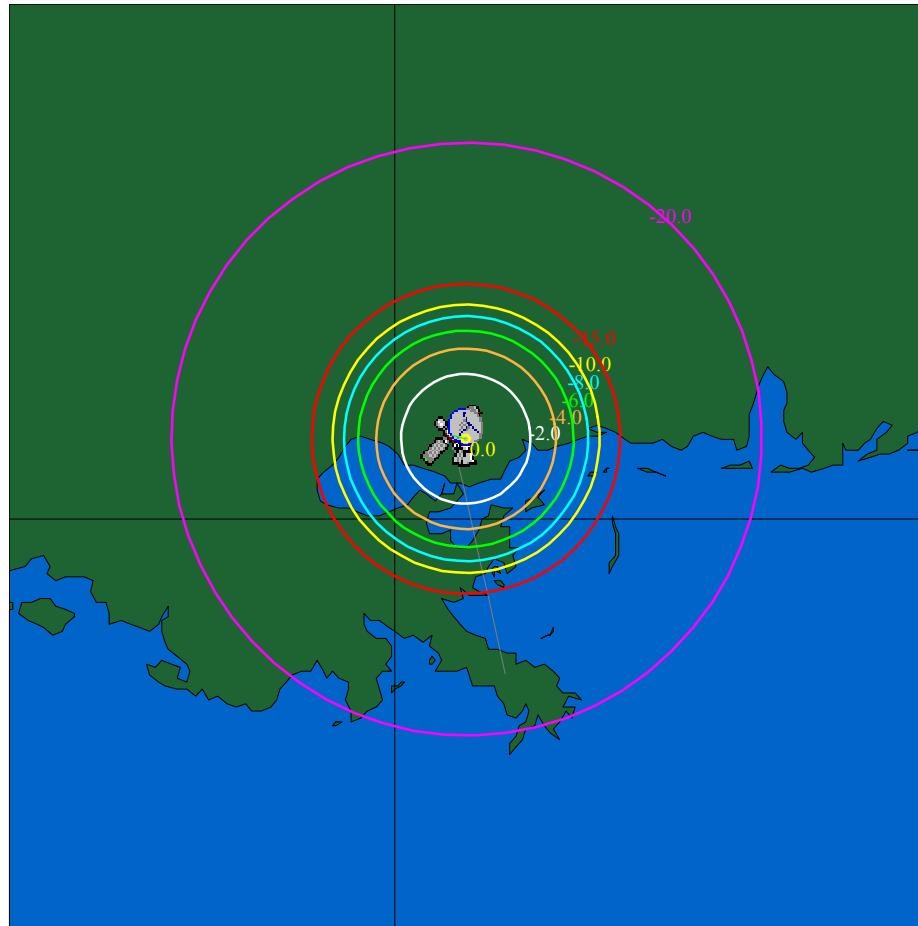
# Wideband Spectral Mask



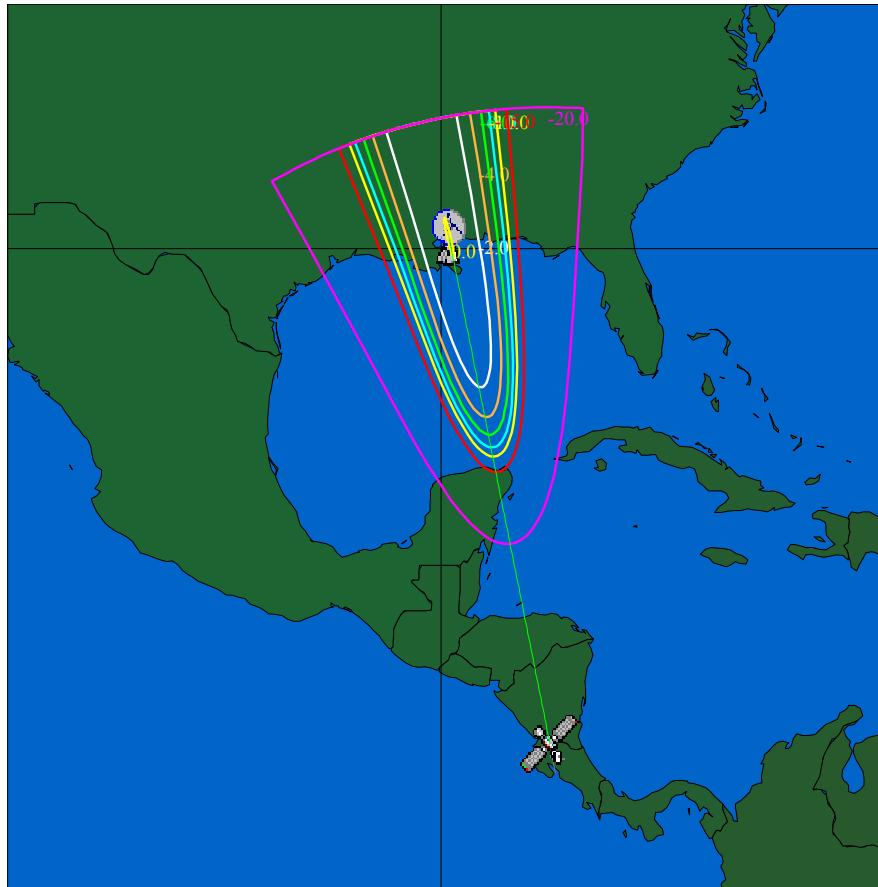
# Wideband Antenna

- Three independent steerable antennas
  - Two axis gimbaled
  - Radial slot-line arrays
  - Beamwidth – 7 degrees
  - Two beams are LHCP
  - One beam RHCP

# Wideband Antenna Contours (90 degree Elevation)



# Wideband Antenna Contours (5 degree Elevation)



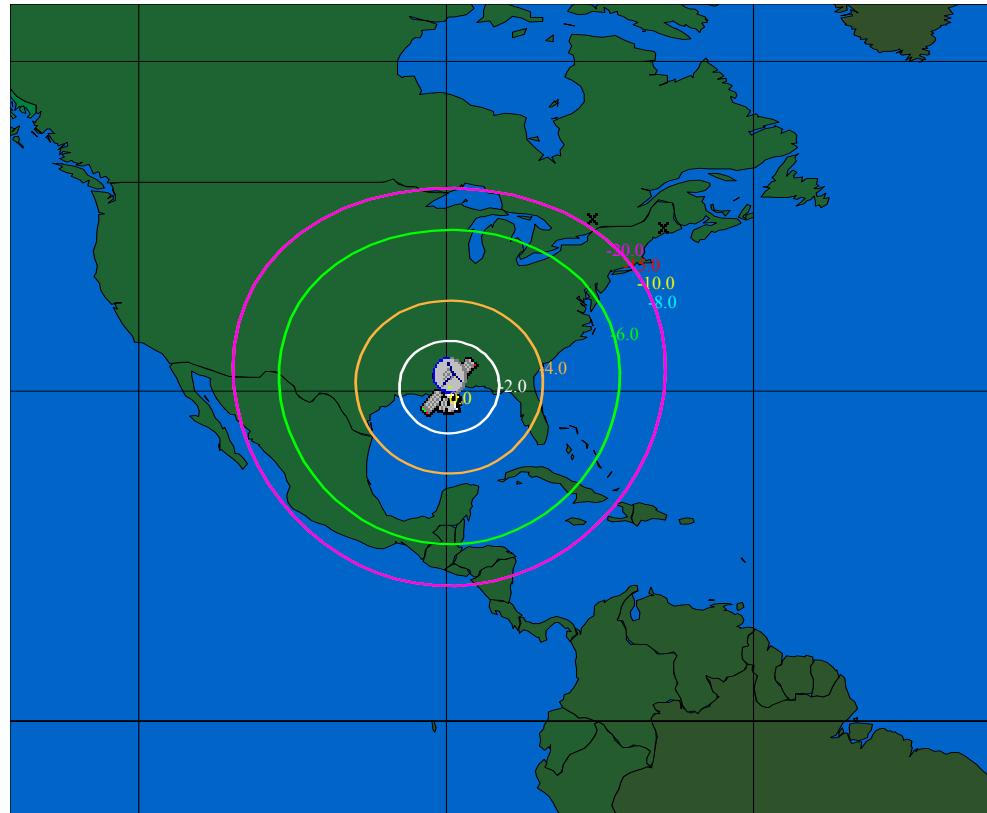


# Telemetry Downlink Characteristics

Parameter	Value	Units
Carrier Frequency	8380	MHz
Data rate	1.048576	Mb/s
Modulation	QPSK	
FEC Coding	Viterbi, r=1/2, K=7	
EIRP, nominal	9	dBW
Noise Equivalent Bandwidth	1.048	MHz
Noise temperature	141.3	Degrees k
Emission Designator	1M05G7D	
Availability objective	99.7	%
BER objective	$10^{-6}$	

- Normal mode, hemispherical antenna pattern
- Contingency mode, near omni-directional antenna pattern

# Telemetry Antenna Contours

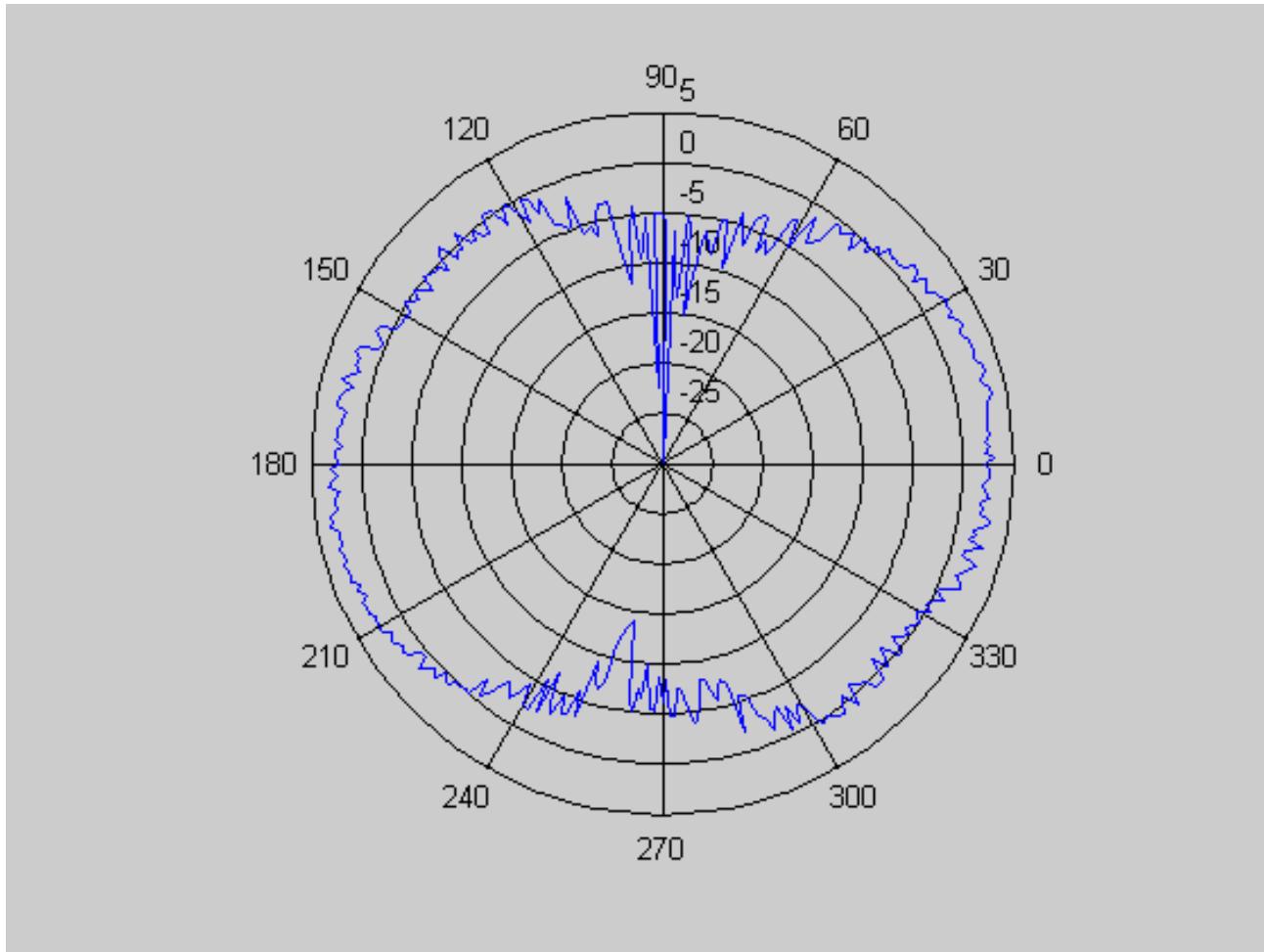




# Command Uplink Characteristics

Parameter	Value	Units
Carrier Frequency	2050	MHz
Data Rate	2.0	kb/s
Subcarrier frequency	16.0	kHz
Subcarrier modulation	BPSK	
Carrier modulation	PM	
Carrier modulation index	1.2	radians
EIRP, nominal	52.36	dBW
Noise Temperature	777.1	Degrees k
Emission Designator	40K0G2D	
Availability objective	99.7	%
BER objective	$10^{-6}$	

# Uplink Antenna Pattern



# Earth Stations

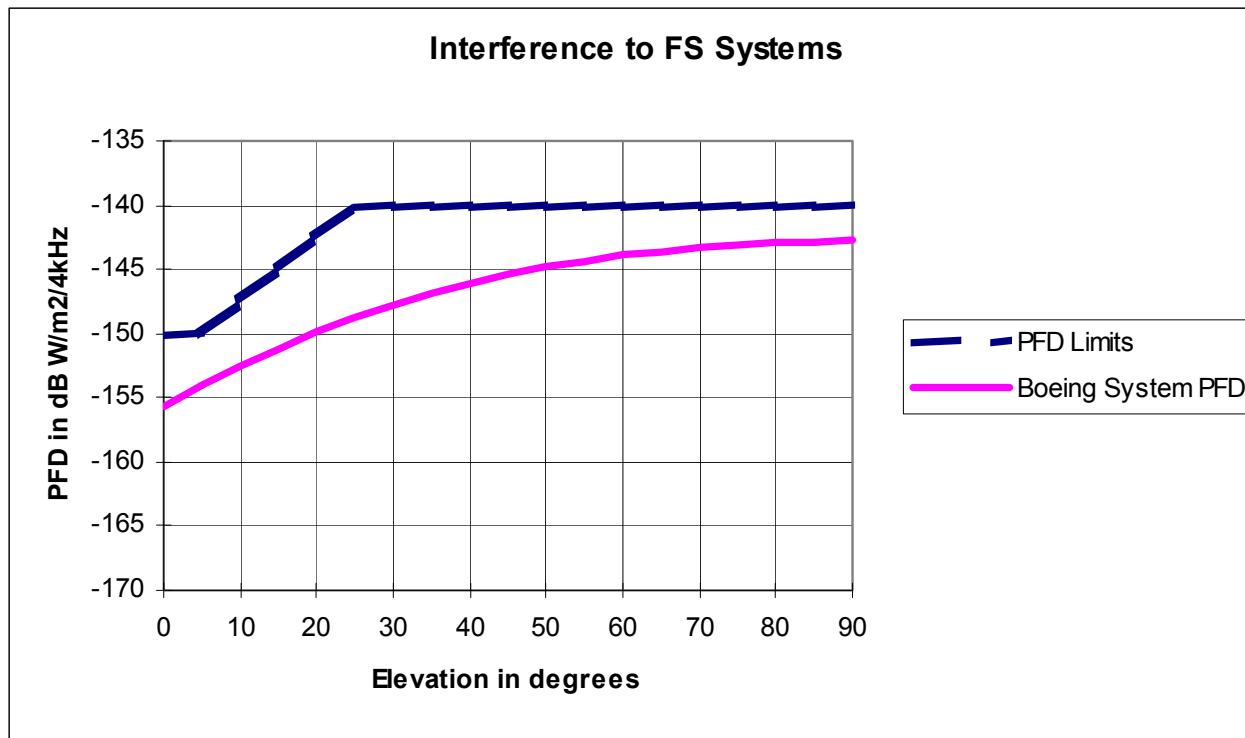
- Two dedicated remote ground terminals (RGT)
  - Fairbanks, Alaska
  - Stennis, Mississippi
- International Cooperator sites
  - Landsat IC sites



# Typical Earth Station Characteristics

Parameter	Value	Units
Antenna peak gain (X-band receive)	55.5	dB
Receiver Noise Temp, clear sky	141.3	dB
Antenna peak gain (S-band transmit)	43.8	dB
Transmitter EIRP	55.7	dBW

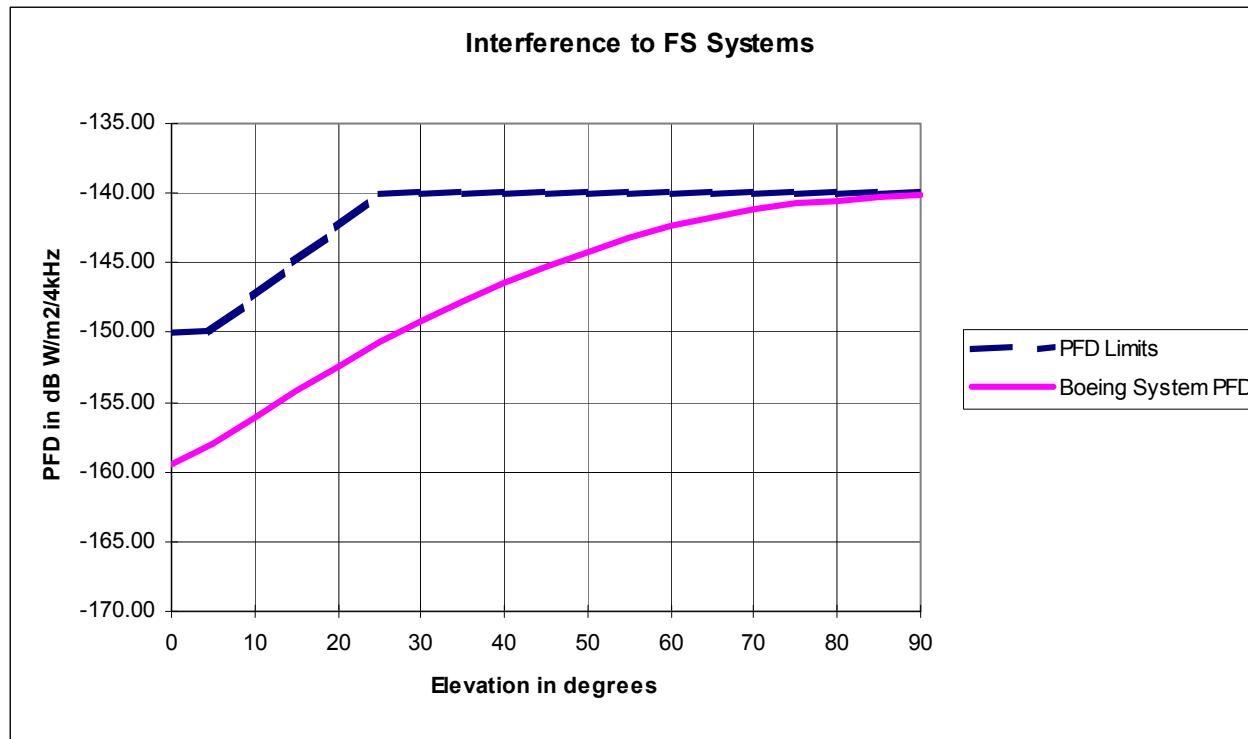
# Wideband PFD at Earth Surface



Considers worst case transmit EIRP.

3.55 dB greater than nominal

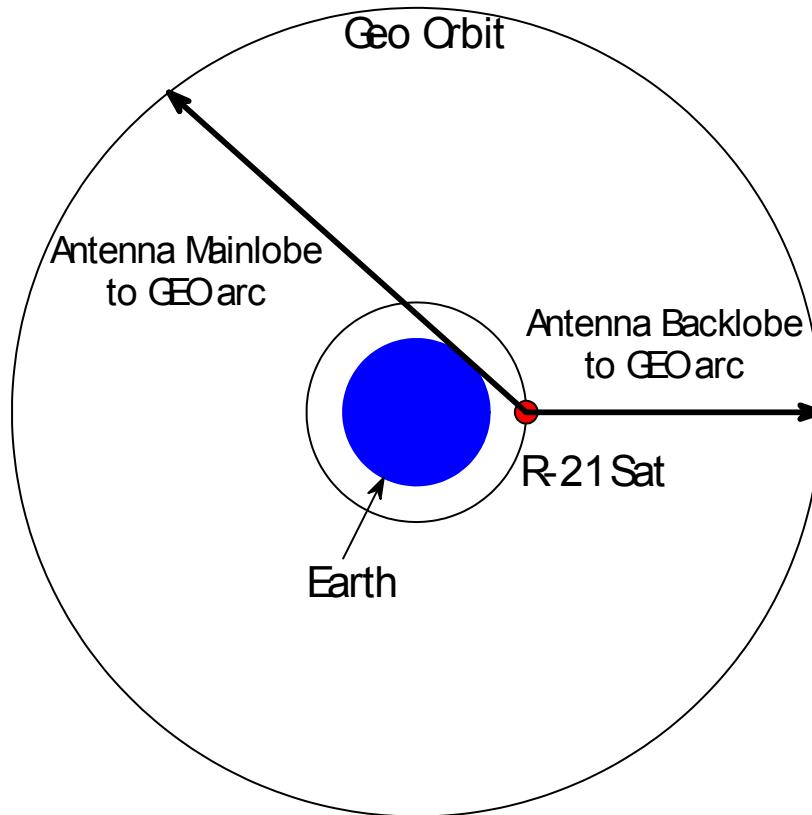
# Telemetry PFD at Earth Surface



Considers worst case transmit EIRP.

2.95 dB greater than nominal

# PFD at GEO Arc (Considerations)



# Wideband PFD at GEO Arc

- Worst case EIRP, 3.55 dB > nominal
- Backlobe
  - 3 simultaneous transmissions
  - 16 dB margin
- Mainlobe
  - 2 simultaneous transmissions
  - 1.8 dB margin

# Telemetry PFD at GEO Arc

- Worst case EIRP, 2.95 dB > nominal
- Backlobe
  - Assumes contingency mode with omni pattern
  - 0.14 dB margin
- Mainlobe
  - Greater margin due to
    - Antenna pattern loss
    - Greater range



# Wideband PFD in DSN Band

Parameter	Value	Units
EIRP	32.15	dBW
Filter sidelobe	-80	dB
# simultaneous transmissions	2	
Satellite altitude	705	km
Bandwidth (NEB)	200	MHz
PFD	-255.81	dBW/m <sup>2</sup> -Hz
PFD limit	-255.1	dBW/m <sup>2</sup> -Hz
Margin	0.71	dB

# Telemetry PFD in DSN Band

Parameter	Value	Units
EIRP (max)	11.95	dBW
Filter sidelobe	-80.0	dB
# simultaneous transmissions	1	
Satellite altitude	705	km
Bandwidth (NEB)	1.048	MHz
PFD	-256.22	dBW/m <sup>2</sup> -Hz
PFD limit	-255.1	dBW/m <sup>2</sup> -Hz
Margin	1.12	dB

# Inter-system Interference

- Criteria – 6 %  $\Delta T/T$
- Location – Fairbanks, Alaska
- Interference, Resource-21 to EOS PM
  - Discrimination angle – 21.92 degrees
- Interference, EOS-PM to Resource-21
  - Discrimination angle – 25.97 degrees
- Equivalent to 2.75 degrees Earth central angle.
- Orbit crossings result in interference alignment
  - Predictable events
  - Requires coordination

# X-band vs. Ka-band

## X-band Issues

- Worldwide primary allocation
- US non-gov. use allocation by footnote on case-by case basis
- Potential interference with adjacent DSN
- Downlink coordination may be required with other systems

## Ka-band Issues

- ITU Worldwide primary allocation, except
- \*US gov allocation secondary
- \*US non-gov. allocation secondary space-to-space. No space-to-Earth
- Higher rain attenuation, lower availability

\* Current NPRM in process to change allocations to conform to ITU worldwide allocation